Draft - Corrective Action Decision

National Cooperative Refinery Association Refinery
2000 South Main Street
McPherson, Kansas 67460

Project Code – C5-059-00057

Kansas Department of Health and Environment
Environmental Remediation

Prepared by:

Kansas Department of Health and Environment
Division of Environment
Bureau of Environmental Remediation
Curtis State Office Building
1000 Jackson St, Suite 410
Topeka KS, 66612

October 2019

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS USED IN THIS DOCUMENT

ARARs	Applicable or Relevant and Appropriate Requirements
AST	Above-ground Storage Tank
bgs	Below Ground Surface
CI	Comprehensive Investigation
CAD	Corrective Action Decision
CAS	Corrective Action Study (report)
COC	Contaminants of Concern
COPC	Contaminants of Potential Concern
1,2-DCE	1,2-Dichloroethylene (cis/trans or total)
EPA	[United States] Environmental Protection Agency
EUC	Environmental Use Control
KDHE	Kansas Department of Health and Environment
MCL	Maximum Contaminant Level
mg/kg	Milligrams per Kilogram
mg/L	Milligrams per Liter
MNA	Monitored Natural Attenuation
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
OSHA	Occupational Safety and Health Administration
PCBs	Polychlorinated Biphenyls
PCE	Tetrachloroethylene (aka Perchloroethylene)
RAO	Remedial Action Objective
RSK	Risk-based Standards for Kansas, RSK Manual, 5th Version (Oct 2010, rev 2014 and 2015)
TCE	Trichloroethylene
VC	Vinyl Chloride
VI	Vapor Intrusion
VOCs	Volatile Organic Compounds
µg/kg	Micrograms per Kilogram
µg/L	Micrograms per Liter

GLOSSARY

Administrative Record – The body of documents that forms the basis for selection of a particular response at a site. Parts of the Administrative Record are available in an information repository near the site to permit interested individuals to review the documents and to allow meaningful participation in the remedy selection process.

Aquifer – An underground layer of rock, sand, or gravel capable of storing water within cracks and pore spaces or between grains. When water contained within an aquifer is of sufficient quantity and quality, it can be used for drinking or other purposes. The water contained in the aquifer is called groundwater.

Applicable or Relevant and Appropriate Requirements (ARARs) – The federal and state environmental laws that a remedy will meet. These requirements may vary among sites and alternatives.

AOC – Area of Concern

Capital Costs – Expenses associated with the initial construction of a project.

CFR – Code of Federal Regulations

Corrective Action Decision (CAD) – The decision document in which KDHE selects the remedy and explains the basis for selection for a site.

Exposure - Contact made between a chemical, physical, or biological agent and the outer boundary of an organism. Exposure is quantified as the amount of an agent available at the exchange boundaries of the organism (e.g., skin, lungs, gut).

Groundwater – Underground water that fills pores in soils or openings in rocks to the point of saturation. Groundwater is often used as a source of drinking water via municipal or domestic wells.

Maximum Contaminant Levels (MCLs) – The maximum permissible level of a contaminant in water that is delivered to any user of a public water system.

Monitoring – Ongoing collection of information about the environment that helps gauge the effectiveness of a cleanup action. For example, monitoring wells drilled to different depths at the site would be used to detect any downward migration of the plume.

Monitored Natural Attenuation - Allowing natural processes to remediate pollution in soil and groundwater while site conditions are routinely monitored.

National Oil and Hazardous Substances Pollution Contingency Plan (NCP) – The federal regulations that guide the Superfund program (40 CFR, Part 300).

Plume – A body of contaminated groundwater flowing from a specific source.

Remedial Investigation (RI) - A study of the source, nature, and extent of contamination.

RCRA – Resource conservation and Recovery Act (1976) (40 CFR parts 239 – 282)

Risk - The probability of adverse health effects resulting from exposure to an environmental agent or mixture of agents.

SWMU – Solid Waste Management Unit

Tier 2 Level – Calculated risk-based cleanup value for a specific contaminant. These values can be found in Appendix A of the *Risk-Based Standards for Kansas (RSK) Manual.*

Threshold - The dose or exposure below which no harmful effect is expected to occur.

Toxicity – A measure of degree to which a substance is harmful to human and animal life.

TSCA – Toxic Substances Control Act (1976) (40 CFR-Chapter I-Subchapter-R Part 761)

Vapor Intrusion – The migration of contaminants from the subsurface into overlying and/or adjacent buildings.

Volatile Organic Compounds (VOCs) – Carbon compounds, such as solvents, which readily volatilize at room temperature and atmospheric pressure. Most are not readily dissolved in water, but their solubility is above health-based standards for potable use. Some VOCs can cause cancer.

1 PURPOSE OF THE DRAFT CORRECTIVE ACTION DECISION

The primary purposes of the Final Corrective Action Decision (CAD) for the National Cooperative Refinery Association (NCRA) now known as the CHS Refinery, McPherson, Kansas, Site (Site) are to: 1) summarize information from key Site documents including the Final Comprehensive Investigation (CI), Final Focused Corrective Action Study (CAS), and routine ground water monitoring (Underground Oil Recovery – UGOR) reports; and, 2) briefly describe the preferred remedial alternative for addressing soil and groundwater contamination detailed in KDHE Administrative File documentation.

KDHE is making available to the public for review technical information presented in the CI, CAS, groundwater monitoring reports, and other documents contained in the Administrative Record file. The Administrative Record file includes all pertinent documents and Site information that form the basis of this Draft CAD and supports the overall rationale for selection of the preferred and final remedy for the Site. The KDHE Administrative Record file is available for public review during normal business hours at the locations shown in Highlight 1-1. The public comment period runs October 1, 2019 through November 15, 2019.

Highlight 1-1: Public Information

Administrative Record File

Kansas Department of Health and Environment
Bureau of Environmental Remediation
1000 SW Jackson Street; Suite 410
Topeka, Kansas 66612-1367

Contact: John K. Cook, PG
Phone: (785) 296-8986
E-mail: john.cook@ks.gov

Web:
http://www.kdheks.gov/remedial/site_restoration/NCRARefinery.html

Local Information Repository

Various environmental investigations and/or interim [remedial] actions have been conducted on behalf of CHS Refinery under the auspices of the original KDHE 2000 Consent Order - Case No. 00-E-0190 and the 2012 Consent Agreement and Final Order (CAFO) Amendment, also Case No. 00-E-0190. The CAFO was later amended to reflect the change in name and ownership (from NCRA to CHS). These investigations and/or interim actions summaries found in this Draft CAD are derived from Administrative File information, but mainly from the *Final Focused Corrective Action Study Report* (Environmental Resources Management 2018).

1.1 RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) FIRST PROCESS

A significant modification in performing RCRA Corrective Actions (CA) was announced by the United State Environmental Protection Agency (EPA), in which a stream-lined approach to performing CA action was presented; it is called the RCRA Facilities Investigation Remedy Selection Track, or RCRA FIRST process.

The RCRA FIRST process ensures selection of a remedy that is both practical and protective of human health and the environmental, while enabling KDHE to accelerate progress towards satisfaction of Government Performance and Results Act (GPRA) 2020 project milestone goals.

More specifically, a Remedy Selection Meeting replaced the need for a robust, wide-ranging analysis of remedial technologies and alternatives in the CAS. After this meeting, CHS then prepared the Focused CAS which serves as a summary of the Remedy Selection Meeting and evaluates the proposed corrective measures against the applicable screening criteria specified in Federal and State guidance. By taking this approach, CHS satisfies the CAFO requirements for a CAS, while stream-lining the overall remedy selection process.

2 SITE BACKGROUND

2.1 SITE LOCATION AND SETTING

The Refinery property is located at 2000 South Main Street, McPherson, Kansas (Figure 1). For the remainder of this document, the Site will be referred to as either the CHS McPherson Refinery (Refinery) or the Site. The Refinery includes 1,300 acres of which approximately 460 acres are restricted access. Land use surrounding the Refinery is primarily agricultural. However, residential and commercial properties are also located near the Refinery property boundary. The nearest residential areas are approximately 0.5 mile to the south and up-gradient relative to local groundwater flow (Figure 2). It is important to note that groundwater flow is artificially controlled in part by the operation of Refinery production and light, non-aqueous phase liquid (LNAPL) containment/recovery wells. Production wells dominated groundwater flow prior to 1988. Since then the LNAPL recovery system (including the groundwater containment wells) has supplanted groundwater flow control.

The Main Process Area includes the crude oil refining and processing units between the former Missouri Pacific Railroad (now Union Pacific) and the Union Pacific Railroad lines north of the South Tank Farm and south of Iron Horse Road (Figure 2). Most of the process units and equipment within the main process area are situated over concrete slabs with perimeter curbs. The remaining portions of the Main Process Area are either paved or covered with gravel.

2.2 SITE DESCRIPTION, HISTORY AND OPERATION SUMMARY

Refinery operations began in 1933 and continues to this day, running 24-hours per day, 7 days a week. The Refinery processes approximately 100,000 barrels of crude oil per day, (except when the Refinery is shut down for periodic repair, maintenance and/or installation of new equipment.) Crude oil is supplied to the Refinery primarily through pipelines. However, a small quantity of mixed oil products is delivered by truck. Products produced include consumer-grade fuel and various petrochemical feedstocks (gasoline, diesel fuel, propane, fertilizer) and coke.

The Focused CAS (ERM 2018) notes that drainage from the bermed containments for the South Tank Farm generally flows west and north to the low corner of each bermed area. The various berms are connected by piping with manually-operated valves. There are various structures that collect, divert, and route *uncontaminated storm water* [emphasis added] to the storm sewer system.

The Focused CAS notes that storm water runoff (through most of the Main Process Area) is collected into the storm sewer system. The storm sewer then routes the surface runoff northward to the Equalization Basin (also known as Solid Waste Management Unit (SWMU 07) and Aeration Pond (SWMU 08) located north of Iron Horse Road.

Runoff from those portions of the Main Process Area that are not equipped with a storm sewer is collected in the Oily-Water Sewer System for eventual treatment in the wastewater treatment plant (WWTP). Oily process wastewater treated at the WWTP discharges into an equalization basin where it can either be recycled for use in the Refinery or directed to the Class I, Non-Hazardous Waste Injection Wells for the Refinery.

Non-contact cooling water and re-circulated pond water is collected by the storm sewer and discharged to an open channel located just northwest of the Main Process Area. This water is then routed to an aeration pond where it receives mechanical aeration enhancing biological treatment before it is released to the 10-Acre Effluent Lagoon (lagoon). Lagoon water is re-circulated for use as fire-fighting and utility water. Under extreme circumstances excess water from the lagoon can be discharged to Bull Creek under authority of the National Pollutant Discharge Elimination System (NPDES)-permitted outfall (Kansas Permit No. I-LA11-PO02, Federal Permit No. KS0000337).

Bull Creek flows through the northern portion of the Refinery and historically received treated wastewater from the lagoon. However, since the Refinery began directing treated wastewater to the Class I Non-Hazardous Waste Injection Wells in March 2004; regular discharges to Bull Creek have been mostly eliminated.

For a detailed discussion of the regional and local geology and hydrogeology please consult information contained in *Document 5 – Comprehensive Investigation Report* (ERM 2005) found in the Administrative File and/or the KDHE Website link for the Site. CHS has also developed a Conceptual Site Model (CSM) which includes a detailed Site geologic model. This model is discussed in detail in the *Final Focused Corrective Action Study Report* (ERM 2018).

In general, the Refinery lies within the McPherson Valley, an area characterized by unconsolidated slope and stream deposits that collectively make up the McPherson Formation. The McPherson Formation, which contains the principal groundwater resource (Equus Beds) for Refinery operations and the region in general, is 170 to 190 feet thick. The groundwater surface of the Equus Beds historically began around 50 feet below ground surface (bgs). However, groundwater pumping at the Refinery has depleted this top zone and is no longer present. The current saturated zone at the Refinery begins around 75 to 90 feet bgs. Due to changes in the bedrock topography across the Refinery this groundwater zone varies in saturated thickness ranging between 74 feet on the east side of the Refinery to 128 feet on the west side.

Groundwater flow in and around the Refinery is extremely complex and is in part the result of natural hydrogeologic complexities. Groundwater flow is further complicated by operation of water-supply wells in and around the Refinery Main Process Area. The operation of these water-supply wells (and others in the area) have induced a broad cone of depression. Chloride recovery wells not directly associated with the LNAPL recovery system or process wells are located in the eastern portion of Refinery property and also contribute to the artificially-induced groundwater flow conditions.

As a predictive tool for managing LNAPL containment and pumping rates from the water-supply and recovery wells, CHS developed and utilizes a multilayer groundwater flow model including a graphical representation of particle tracking (Figure 3). This model and its use are more thoroughly discussed in Section 5.3 of the Final Focused CAS.

2.3 HAZARDOUS WASTE LANDFARM MANAGEMENT (HWLF)

As documented in the updated Post-Closure Plan the HWLF operated under interim closure status from June 1986 until closure in 1990. No wastes were added to the HWLF after closure and post-closure activities were initiated. HWLF closure activities were completed on June 19, 1990. The HWLF closure report was accepted by KDHE on October 8, 1990 and is included in the Administrative File.

Assuming a 30-year performance period, the post-closure period was anticipated to terminate in October 2020. However, in November 2018 KDHE proposed and CHS accepted the transfer of Post-Closure Care and HWLF groundwater monitoring oversight from the KDHE, Bureau of Waste Management (BWM) to the Bureau of Environmental Remediation (BER) while also allowing the Post-Closure to terminate.

HWLF groundwater monitoring wells were sampled semiannually from October 1992 until October 1995, quarterly sampling resumed in April 1996 and continued through December 2010. With KDHE approval, the HWLF groundwater has been monitored semiannually since January 2011.

Initial HWLF groundwater monitoring results note statistically significant levels of petroleum hydrocarbons in the groundwater. However, a *Groundwater Demonstration Report* (Roberts/Schornick & Associates, Inc., May 1998) concluded that, based on an investigation performed by PRC Environmental Management, Inc. (PRC), past operations at the adjacent [Former] El Paso Terminal likely released petroleum hydrocarbons. The report further concluded that benzene, toluene, ethylbenzene, and xylene (BTEX) compounds and various metals detected in HWLF monitoring wells likely migrated beneath the HWLF from the Former El Paso Terminal facility.

Additional investigation and remediation work were completed at the EL Paso Former Terminal (during El Paso ownership). This work included both groundwater monitoring and use of a pilot-

scale soil vapor extraction system. An Interim Corrective Action Decision (CAD) was issued by KDHE for the former terminal site in April 2013. The CAD requires ongoing groundwater containment and LNAPL skimming. The terminal site property was purchased by CHS in 2013, and ongoing monitoring and any future remediation responsibilities were incorporated into the Amended CHS CAFO (2012).

The HWLF will remain under cover of the concrete heat exchanger bundle cleaning slab for the life of the slab. This will prevent [potential] exposure to wastes remaining in the soil. CHS acknowledges that hazardous wastes are generated and stored at this slab and this may constitute a new Solid Waste Management Unit (SWMU) for the Refinery. Therefore, the operation, maintenance, and post-closure care procedures to be implemented for the concrete heat exchanger bundle cleaning slab will be presented in the Refinery Corrective Action Plan (CAP).

Finally, financial assurance obligations for Refinery corrective actions per the CAFO, include the estimated remaining post-closure costs for the HWLF.

3 SITE CHARACTERIZATION, INVESTIGATIONS AND ASSESSMENTS SUMMARY

The characterization, investigation and assessment of the Refinery SWMUs and Areas of Concern (AOC) identified in the 2012 CAFO amendment were conducted in a phased manner. These phased activities include: 1) Comprehensive Investigation (multiple documents); 2) Risk-Based Screening Evaluation (RBSE); 3) Data Gaps Sampling Program; 4) Ecological Risk Assessment (ERA); 5) Human Health Risk Assessment (HHRA); 6) Vapor Intrusion Evaluation; 6) North Area Soil Investigation; and, 7) added characterization of Exposure Area (EA) 08.

3.1 CHARACTERIZATION/INVESTIGATION FINDINGS

Each SWMU and Area of Concern (AOC) requiring investigation was placed, based on the priority assigned to the unit, into a group referred to as a "Study Area". Priority assignments, and subsequently Study Area designations were based on the various operational requirements and construction activities related to the Clean Fuels Project. The highest priority was assigned to the Clean-Fuels project. The remaining designations were based on the potential for human exposure and were ranked high to low.

During Clean Fuels Project construction activities, it was expected that contaminated soil would be encountered. In consultation with KDHE, CHS saw this as an opportunity to more thoroughly characterize the Site by sampling and analyzing potentially impacted soil, and when possible address soil-source removal. It was however not intended to expand characterization to depths and/or areas not required by the design and/or engineering requirements of the Clean-Fuels project. Thus, additional characterization, if needed was completed in later CI phases.

During the CI activities 232 locations were sampled with a total of 764 samples collected: 714 samples were surface and subsurface soil samples; 32 were sediment samples; and, 18 were surface

water samples. Results of this early CI sampling are reported in the 2005 CI Report (ERM, 2005) and include the following:

1. The primary constituents of concern for the Refinery included volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs); primarily polycyclic aromatic hydrocarbons [PAHs]), total petroleum hydrocarbons-gasoline range organics (TPH-GRO), total petroleum hydrocarbons-diesel range organics (TPH-DRO), cyanide (surface water only), and metals (primarily arsenic and lead) in soil and sediment.

2. Various soil sample locations and depths noted free-phase hydrocarbons, hydrocarbon odors and black staining. Free phase hydrocarbons (LNAPL) are also pervasively present underlying the Refinery (Figure 4).

3. Lead and arsenic were the only inorganic constituents detected above Risk- Based Standards for Kansas, RSK Manual – 5th Version (October 2010, revised March 2014 and September 2015) (RSK) in soil and sediment samples. The majority of the arsenic RSK exceedances are associated with the 2003 version of the RSK Tier 2, soil to-groundwater protection pathway (5.84 mg/kg) screening values.

   Please note that KDHE's 2003 version of the RSK Manual included soil-to-groundwater values for selected inorganic parameters, arsenic included. KDHE however rescinded all soil-to-groundwater standards for [heavy] metals in the 2007 version of the RSK document. Thus, the soil-to-groundwater values are cited in the Final CAS as a line of evidence supporting little cross-contamination risk associated with arsenic.

4. Arsenic was detected above the direct contact (soil) exposure pathway RSK (38 mg/kg) in 2 of 746 soil and sediment samples. However, arsenic was detected in 19 of the 20 samples collected from background boring locations. These back-round detections were above the soil-to-ground water protection pathway RSK in three samples.

5. Sulfide [reactive] was detected in samples collected from Bull Creek (please note that RSK values have not been established for reactive sulfide). This parameter is typically used to determine if a waste material is considered hazardous (due to RCRA waste reactivity characteristic).

6. Total chromium, lead, nickel, and total cyanide were detected at various locations in surface water (Bull Creek). These exceedances of the surface water quality standards were observed both upstream and downstream of discharge points from the Refinery are not conclusive as to the source(s) of the constituents.

7. The groundwater quality monitoring system surrounding the Refinery consists of nine "zero-line" wells screened in the upper portion of the [existing] Equus Beds (Figure 5). Groundwater samples from these zero-line wells are collected on a quarterly basis and analyzed for parameters customarily associated with petroleum refining operations (VOCs).

8. BTEX (benzene, toluene, ethylbenzene and total-xylenes) were detected in Zero-Line well ZL-3. These detections were attributed to the closed El Paso Terminal located southeast and hydraulically upgradient of well ZL-3. Trace levels of other VOCs in well ZL-1 were detected; however, these detections are below the RSK groundwater screening value.

9. As part of the Clean-Fuels Project construction activities (in and around several of the AOCs and SWMUS) contaminated soil was removed from the affected areas and handled per the Soil Waste Management Plan (SWMP). These construction activities are in effect functioning as interim removal actions.

3.2 VAPOR INTRUSION EVALUATION SUMMARY

Potential vapor intrusion pathways for the Refinery were evaluated to supplement the Human-Health Risk Assessment (HHRA). An Addendum to the HHRA Report (ERM, 2016) was prepared consistent with available EPA and KDHE guidance documents and submitted to KDHE. In this addendum, CHS presented the vapor intrusion pathway evaluation.

The conclusions presented in the Vapor Intrusion Addendum for the Refinery HHRA Report include:

- The petroleum vapor intrusion (PVI) exposure pathway has been evaluated for the Refinery and does not pose excess risk or hazard for the full-time indoor Site worker at the Refinery given current conditions.

and

- Due to the uncertainty inherent in forecasting future conditions, qualitative and quantitative data were evaluated for a future scenario. The assessment indicates that PVI into a hypothetical building without engineering control is not anticipated to be a concern for most Refinery areas.

3.3 NORTH AREA SOIL INVESTIGATION SUMMARY

In July 2015 during the installation of an oil pipeline north of the 10-Acre Effluent Lagoon, petroleum impacted soil was discovered. Soil sampling in this area, referred to as the "North Area" was conducted in September and November 2015.

Impacted soil with constituent concentrations above the RSKs was typically identified visually and/or by a petroleum odor. On either side (north and/or south) of the southernmost natural gas pipeline visually identified impacted soil was typically encountered between 4 and 10 feet bgs.

Petroleum constituents (TPH-DRO, and TPH-GRO) concentrations detected in North Area soils were compared to the soil pathway and the soil-to-groundwater pathway for both residential and non-residential RSK scenarios. TPH-DRO concentrations exceeded the soil pathway RSKs at 17 locations and the soil to groundwater pathway RSKs at 15 locations. TPH-GRO concentrations exceeded the soil pathway RSKs at three locations and the soil-to-groundwater pathway RSKs at nine locations.

Lead analytical results were also compared to the soil pathway RSKs for the residential and non-residential scenarios. Concentrations of lead exceeded the soil pathway RSKs at 16 locations.

VOC and SVOC concentrations in North Area soil were compared to the soil pathway RSKs and the soil-to- groundwater pathway RSKs for both residential and non-residential scenarios. PAH compounds (Benzo(a)anthracene and benzo(a)pyrene) were detected above residential and non-residential soil pathway RSKs. No other soil analytical results noted VOC and/or SVOC concentrations above the applicable soil pathway RSKs.

Multiple VOCs and SVOCs, including naphthalene, benzene, and 1,2,4-trimethylbenzene, were detected at one or more sample locations at concentrations exceeding the nonresidential RSKs for the soil-to-groundwater pathway. However, groundwater in this area of the Refinery property has been documented to be around 89 feet bgs thus providing nearly 90 feet of separation between the soil-source area and the groundwater surface. Thus, it is not expected to be a completed exposure pathway.

In the perimeter borings, concentrations of TPH-DRO, TPH-GRO, and lead were below the soil pathway and soil-to-groundwater pathway RSKs for the residential scenario; indicating that the horizontal extent of petroleum and lead impacts at the Site have been delineated.

3.4 POST-ASSESSMENT ACTIVITIES SUMMARY

NuStar installed a second petroleum pipeline through the area in mid to late 2016. CHS provided the analytical data collected during the North Area Soil Investigation to NuStar in advance of the pipeline construction for planning purposes. During the construction of the second pipeline, NuStar managed the soil in accordance with the Refinery Soil-Waste Management Plan (SWMP) in effect at the time. Clean soil was used to complete backfilling of the pipe trench at the surface.

In summary, the findings from characterization and investigation activities conclude that soil and groundwater contamination, associated with petroleum refining operations including: petroleum hydrocarbon-related contaminants and heavy metals, exceed the RSK, Tier 2 risk-based screening values. It is these exceedances that form the basis supporting investigation and cleanup requirements.

4 INTERIM CORRECTIVE ACTIONS SUMMARY

Various interim corrective actions have been implemented at the Refinery since 1987. These corrective actions have included:

1. Hydraulic containment of LNAPL and impacted groundwater;

2. Recovery of petroleum LNAPL;

3. Removal of impacted soils and on-Site treatment (landfarming) and/or off-Site disposal (i.e. during Clean-Fuels Project construction and other general infrastructure construction projects);

4. Removal of waste and debris and off-Site disposal;

   and,

5. Construction of barriers (i.e., building foundations, concrete or asphalt pavement) between impacted media and potential receptors.

4.1 HYDRAULIC CONTAINMENT AND LNAPL RECOVERY SUMMARY

Five [large] water supply wells located in and around the Main Process Area have established a dominant and pervasive cone of depression. Chloride recovery wells located in the eastern portion of the Refinery property also contribute to the induced cone of depression. As a predictive and management tool for balancing pumping rates from the supply and recovery wells, CHS has developed, calibrated and utilized a multilayer groundwater flow model for the Refinery. This model was also integrated as a component of the Conceptual Site Model.

The Underground Oil Recovery (UGOR) Program for the Refinery was started in August 1987. CHS has recovered nearly 217,270 barrels (9,125,340 gallons) of LNAPL from atop the Equus Beds Aquifer underlying the Refinery through 2016 (Trihydro, 2017). Recovered fluids are separated with the LNAPL reintroduced into the refining process. The remaining water is then treated at the Refinery WWTP. Active collection of LNAPL was conducted into 2008 by wells equipped with hydrocarbon recovery pumps (up to six monitoring wells and one supply well). However, due to significant reduction of LNAPL mass, the UGOR Program transitioned from continuous pumping to monthly “slurping” of selected wells. During the 2016 LNAPL recovery activities, approximately 27.6 barrels or 1,160 gallons of LNAPL were recovered (Trihydro, 2017).

The CHS Refinery groundwater monitoring program verifies the extent of LNAPL and the performance of LNAPL recovery efforts. The program also assesses groundwater quality at the former El Paso Terminal and the CHS Refinery perimeter zero-line wells. Annual reports are

submitted to KDHE summarizing the groundwater monitoring data. These reports are available in the KDHE Administrative File for review.

4.2 REMOVAL ACTIONS/CONSTRUCTION/CLEAN-FUELS PROJECT SUMMARY

Notifications regarding Clean Fuels Project construction activities were provided to KDHE by CHS in letters dated April1, 2003 and June 27, 2003. At the request of KDHE, CHS documented the various refinery construction activities providing additional soil characterization analytical data for impacted soils removed from construction project areas. Unless otherwise noted contaminated materials and/or wastes removed during the Clean Fuels Project were placed in the permitted Solid Waste Landfarm. These construction activities are noted in full in the Administrative File.

5 HUMAN HEALTH AND ECOLOGICAL RISK SUMMARY

5.1 HUMAN HEALTH RISK ASSESSMENT (HHRA) SUMMARY

The HHRA was prepared following the Risk Assessment Work Plan and applicable technical memoranda. Exposure scenarios, Site-specific exposure assumptions, and risk assessment calculation methods were reviewed and approved by KDHE and EPA before preparing the HHRA.

HHRA activities followed procedures outlined in the EPA reference document *Risk Assessment Guidance for Superfund* (aka - RAGS; EPA, 1989, 1991 a and b, 2004, and 2009) and were performed assuming the absence of any engineer/process controls or remedial actions that might mitigate potential exposure. Potential receptors included: site workers, utility workers, construction workers, and recreational receptors populations.

Chemicals of [Potential] Concern (COPCs) primarily consisted of:

Soil Direct Contact Pathway - arsenic, lead, carcinogenic PAHs, and petroleum mixtures;

Soil to Groundwater Protection Pathway - selenium, PAHs, and petroleum mixtures;

Soil Vapor Pathway (for example, vapor intrusion while trenching/excavation) - Benzene, ethylbenzene, naphthalene, toluene, and xylenes (based on soil vapor data.);

Surface water - Limited list of metals, VOCs or PAHs depending on the water body;

and,

Sediment - Metals, PAHs, VOCs, and petroleum mixtures (for selected SWMUs). The COPC list for sediment was based on constituents that were positively detected since this medium was not subjected to quantitative screening.

The Site-specific groundwater protection (GWP) demonstration project concluded that COPC concentrations reported in soil and sediment are not expected to result in concentrations above residential drinking water standards from partitioning and/or migration to ground water. However, there are known impact to groundwater at the Refinery, resulting from historical petroleum hydrocarbon releases resulting in migration of free phase hydrocarbons to groundwater beneath the Refinery. These historical LNAPL releases form the more significant source for ground water impacts at the Site. Interim measures continue to address the LNAPL plume and impacted ground water.

The Tier 3 exposure scenarios (more thoroughly presented in the HHRA and the Final Focused-CAS) are summarized below and include:

Routine Site Workers

The (calculated) cumulative carcinogenic risk for the routine site worker exposure scenario for all EAs is below the upper-bound EPA cumulative target risk of $1x10^{-4}$. The non-carcinogenic Hazard Index (HI) is less than the screening threshold of 1.0.

A site worker is assumed to be an adult industrial worker involved in day-to-day routine activities within the Refinery boundaries. The site worker is assumed to have routine direct contact with impacted surface soil within a depth interval from 0 to 1 foot below ground surface (bgs). The route of exposure includes incidental ingestion and dermal contact. It is assumed that volatile constituents and dust/particulates may be released from these surface soils and/or waste to ambient air and may be inhaled by this receptor. For purposes of the risk assessment, the presence of surface cover was not considered to eliminate or reduce direct contact exposure. This is a highly conservative assumption.

In addition to the surface soil exposures identified, the site worker is assumed to be exposed to vapors released from the subsurface to outdoor air via inhalation. For the site worker, the presence of pavement and Refinery health and safety policies, which may eliminate or reduce inhalation exposure, have not been incorporated into the quantitative risk assessment. A separate receptor, the indoor site worker, is assumed to be exposed to vapors released from the subsurface to indoor air. Some existing structures, such as control rooms, have engineering features which limit vapor intrusion (as specified in 19 Code of Federal Regulations 1910.119 and American Petroleum Institute Standards 752).

Utility/Construction Workers

Cumulative carcinogenic risk estimates for multimedia exposure exceeded the upper bound EPA target risk of $1x10^{-4}$ and/or HI of 1.0 in selected Exposure Areas (e.g. EAs 1, 5, 7, 8, 9, 10, and 11).

Utility-related activities may take place at the Refinery and potentially result in worker exposure to constituents in surface and subsurface soils in the 0 to 5 feet bgs interval. It is the experience of CHS that exposure in this type of scenario has been and will be short-term (e.g., weeks). The

utility worker is assumed to have direct contact with surface and subsurface soils/waste through incidental ingestion, dermal contact, and inhalation of volatiles and dust particles. CHS health and safety policies require appropriate worker protection during excavation work to reduce potential exposure. However, for purposes of the risk evaluation, these measures were not considered to eliminate or reduce direct contact exposure.

Construction activities, including excavation and may result in exposure to COPCs in surface and subsurface soils in the 0 to 10 feet bgs interval. It is the experience of CHS that exposure in this type of scenario is of limited duration. Examples of construction activities include expansion or capital projects, Clean Fuels Project, recent wastewater treatment plant upgrades, and oily-water sewer replacement in several units. The excavation activities are subject to CHS worker protection policies, although no worker protection measures were assumed for the risk assessment. The construction worker is assumed to have direct contact with surface and subsurface soils/waste through incidental ingestion, dermal contact, and inhalation of volatiles and dust particles.

In addition to the soil exposures construction workers are assumed to be exposed to vapors released from the subsurface to surface outdoor air and outdoor trench air via inhalation. For purposes of the risk assessment, CHS health and safety policies which require appropriate worker protection (e.g., for vapor inhalation) during excavation work were not considered to eliminate or reduce potential exposure.

Recreational Receptor

Cumulative carcinogenic risk and non-carcinogenic hazard estimates for multimedia exposure are below the upper bound EPA cumulative target risk of $1x10^{-4}$ and HI of 1.0 for recreational receptors assumed to visit Bull Creek and the former Pitch Pit.

Under current and future conditions, an older child (e.g., 10 to 18 years) could periodically enter the former Pitch Pit (SWMU 33) which is located north of Bull Creek outside the refinery fence line. Exposure to surface soils (0 to 1-foot bgs) was assumed to occur at the former Pitch Pit. The asphalt-like waste material historically present on the surface at the former Pitch Pit was excavated in September 2009 and disposed off-site at the Reno County Landfill. Soil exposed by the removal action has been sampled and a recreational receptor is assumed to have direct contact with the surface soils through incidental ingestion, dermal contact, and inhalation of volatiles and particulates.

A recreational receptor that visits Bull Creek at the Refinery or downstream of the Refinery is assumed to have incidental contact with surface water (ingestion, dermal contact and inhalation of vapors) and sediment (ingestion and dermal contact). The surface water in Bull Creek is generally at least several feet deep; therefore, dermal contact with submerged sediment is unlikely. The recreational receptor may also potentially be exposed to COPCs in surface water via ingestion of fish caught from Bull Creek.

5.2 ECOLOGICAL RISK ASSESSMENT (ERA)

The Refinery Ecological Risk Assessment (ERA) was prepared following the *Tier 3 Risk Assessment Work Plan* (ERM, 2011) and various technical memoranda approved by KDHE. A conceptual model was developed for the Refinery to evaluate potential ecological exposure in various groupings of feeding guilds birds/mammals to contaminants found in selected areas (SWMUs and AOCs). The potential impact of constituents to fish and benthic invertebrate communities in Bull Creek was also evaluated.

The objectives of the Refinery ERA were twofold:

1. Identify constituents that do not pose an ecological risk thus eliminating these constituents from further evaluation;

   and,

2. Identify constituents that posed potential risk and which may require corrective action.

The following overall conclusions are presented in the Ecological Risk Assessment Report (ERM, 2016):

1. Based on Hazard Quotient "no observed adverse effect level", (HQ_{NOAEL}) estimates for seven constituents of potential ecological concern (COPECs) exceed the target value of 1.0 for one or more upper trophic-level ecological receptors (birds and mammals). For the Canada goose and Belted Kingfisher hazard quotient (HQ_{NOAEL}) for all COPECs were less than 1.0.

2. Based on the Hazard Quotient estimates for lowest observed adverse effect level (HQ_{LOAEL}) no COPECs exceed an HQ of 1.0 for birds and mammals (upper trophic level receptors).

3. Estimated exposure concentrations in Bull Creek surface water are protective of the generic fish community.

4. Estimated exposure concentrations in Bull Creek sediment are protective of the generic benthic invertebrate community. There are possible exceptions to this for barium, selenium, and cyanide (which the estimated HQ_{LOAEL} exceed 1.0).

   The contribution of background levels to the calculated HQ_{LOAEL} for barium and selenium was evaluated in the Uncertainty Analysis and concluded that a large proportion (potentially 100 percent of the estimated hazard quotient) is contributed to background levels of barium and selenium. This is based on downstream sample results consistent with background, or upstream sediment concentrations in Bull Creek.

   Potential hazard from cyanide was further evaluated qualitatively in the Uncertainty Analysis, concluding that the hazard to benthic invertebrates was not significant.

5. Reported constituent concentrations in the soil, surface water and sediment evaluated in the ERA are likely protective of a variety of ecological receptors that may be present at the Refinery. This conclusion is based on comparison of estimated exposure concentrations and/or doses to available benchmarks and toxicity reference values for a variety of selected [potential] receptors.

6 CORRECTIVE ACTION GOALS

Corrective Action Goals (CAGs) were developed to evaluate remedial alternatives based on the expected scope of cleanup that is protective of human health and the environment, is cost effective, and utilizes permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. Site-specific CAGs guided the evaluation of the corrective action alternatives. The corrective action goals for the Site are:

1. Prevent human exposure to Site-related COCs in soil, groundwater, and indoor air in buildings intended for occupancy (that were identified as posing an unacceptable risk in the HHRA and Vapor Intrusion Addendum.)

2. Minimize the potential for [additional] degradation of groundwater.

3. Prevent dissolved phase COCs in groundwater and LNAPL from migrating beyond the facility boundary (Figure 1);

4. Recover LNAPL to the extent practical as defined in the KDHE BER Policy No. BER-041 (Total Petroleum Hydrocarbons [TPH] and Light Non-Aqueous Phase Liquid [LNAPL] Characterization, Remediation and Management);

   and,

5. Effectively manage impacted media on the facility during future ground disturbance activities.

7 CLEANUP LEVELS

Maximum Contaminant Levels (MCLs) and/or the most current KDHE RSKs for residential groundwater are the final cleanup goals for unrestricted future use (and closure) for the Site. However, Alternate Treatment Goals (ATGs) for groundwater may be established as part of the Corrective Action Plan (CAP). ATGs are threshold criteria where *active remediation* [emphasis added] may be modified or terminated. It should be noted that the final clean-up criteria permitting unrestricted future groundwater use are the previously identified MCLs and/or RSK Residential screening values.

The majority of the TPH data is reported as TPH-GRO and TPH-DRO. In September 2015, KDHE BER issued a policy regarding characterization, remediation, and management at TPH-impacted sites (Policy No. BER-041). The policy introduced new parameters for measurement of TPH including Low-Range Hydrocarbons (LRH), Mid-Range Hydrocarbons (MRH) and High-Range Hydrocarbons (HRH). Corrective action activities at the Refinery involving TPH-impacted media will utilize Policy No. BER-041 criteria for the cleanup standards (as applicable).

To aid in the future management and disposition of soils at the Refinery, CHS calculated Site-wide Tier-3 risk-based screening levels using a combination of Site-specific and default values. These screening levels are not cleanup goals. Neither do they supersede the exposure area-specific groundwater protection evaluation. Rather, they serve as a tool to ensure protection of human health and the environment while facilitating soil-waste handling practices and decisions consistent with the SWMP.

8 CORRECTIVE ACTION ALTERNATIVE – RCRA FIRST PROCESS

The evaluation of corrective action alternatives is normally presented as multiple technologies combined into several remedial alternatives. These alternatives are then screened against one another following *National Oil and Hazardous Substances Contingency Plan* (NCP) criteria including: 1) protection of human health and the environment, 2) compliance with Applicable or Relevant and Appropriate Requirements; 3) long-term effectiveness and permanence, 4) reduction of toxicity, mobility or volume through treatment; 5) short-term effectiveness; 6) implementability; 7) cost, 8) State acceptance, and 9) community acceptance.

However, project stake-holders agreed to follow the RCRA Facilities Investigation Remedy Selection Track (FIRST) Toolbox for stream-lining the Corrective Action process. Thus, the Final Focused CAS does not include an exhaustive evaluation of multiple Corrective Action Alternatives, but rather presents the preferred Remedial Alternative without comparison to other alternatives. The preferred alternative is presented in Section 9.0 of this Draft CAD.

The EPA website (https://www.epa.gov/hw/toolbox-corrective-action-resource-conservation-and-recovery-act-facilities-investigation-remedy) presents the following discussion of the RCRA First process,

> "RCRA First distills practical lessons learned and experiences contributed by federal, state, and regulated community representatives involved with investigation and remedy selection worldwide."

The EPA website further states:

> "EPA designed the RCRA FIRST approach to improve the efficiency of RCRA facility investigations and remedy selection at RCRA Corrective Action Facilities. The RCRA FIRST approach:

- Addresses the root causes of delay, such as
    - Unclear or non-specific investigation or cleanup objectives and
    - Lack of specific opportunity and process to elevate differences among stakeholders early in the process.
- Starts with multi-party understanding of the objectives in investigation and remedy selection phases.
- Enhances communication among project stakeholders.
- Promotes the principle of "done right the first time" and avoids re-do loops.
- Advances critical decision-making through rapid elevation to resolve disputes.
- Stays within the technical and regulatory framework of the corrective action program."

9 DESCRIPTION OF THE PREFERRED REMEDY

As discussed during the January 2017 meeting between KDHE and CHS, project stakeholders agreed that based on RCRA First guidance, the fully operational nature of the Refinery and the on-going cleanup, a formal evaluation of all potential remedial alternatives would not provide any value added to the overall path forward. Therefore, CHS developed a list of remedial requirements and recommended corrective action technologies for the McPherson Refinery that include:

- Continue focused LNAPL recovery throughout the Refinery based on LNAPL thickness and transmissivity.
- Monitor hydrocarbon and LNAPL degradation by completing the sampling, analysis, and calculations needed to estimate the rate of Natural Source Zone Depletion (NSZD) in the groundwater and zone of unsaturation (vadose zone). This may include evaluation of potential methods which could cost effectively and significantly increase the rate of dissolved-phase and/or vadose zone NSZD.
- Continue groundwater pumping/containment to maintain hydraulic control of LNAPL and dissolved-phase constituents consistent with the proposed Receptor Management Plan (Focused CAS, Appendix G – ERM 2018).
- Modify the existing EUCA to include the entire CHS Refinery property, maintaining controls preventing consumptive groundwater use and land use inconsistent with impacted media.

- Perform excavation, investigation and, as necessary, soil removal actions minimizing and/or preventing worker exposure to contaminated media. This may include enforcing notification procedures, enhancing engineering controls and/or adhering to performance criteria as noted in the Refinery SWMP and associated health and safety procedures.

- Where source removal cannot be completed, CHS proposes to cap impacted soil with clean soil, structures, concrete or asphalt to prevent direct contact exposure.

- Evaluate and if applicable, design and maintain engineering controls to prevent exposure to vapor-phase hydrocarbons in occupied buildings located above impacted soil and/or LNAPL. Evaluations will be performed consistent with KDHE vapor intrusion guidance and applicable CHS procedures.

- Continue the implementation of process controls, preventative maintenance, Refinery upgrades and response protocols to prevent and/or respond to spills/releases.

- Part of this Remedy is to recognize the remediation activities already implemented and/or completed.

- A critical component of any remedy is consideration of possible changes to current conditions and whether the remedy remains protective of human health and the environment. Therefore, as an element of corrective action planning, CHS has considered the circumstances which would initiate communication with KDHE regarding modifications or additions to the actions being implemented (Contingency Planning). Table 7-6 from the Final Focused CAS summarizes in general terms the various events or circumstances that could cause such modifications or additions to corrective action. The cited table also provides an overview of the steps to be taken. Please note that CHS assumes that communication with KDHE at an early and appropriate time would be foundational to implementation of any additional corrective actions.

10 COMMUNITY INVOLVEMENT

A Public Relations Strategy for the Site was developed by KDHE wherein KDHE encourages the public to provide input and comment. A public notice of the availability of the draft CAD (along with pertinent Administrative File information) will be published in the McPherson Sentinel newspaper on October 1, 2019. In addition, KDHE has established a webpage dedicated to the Site at http://www.kdheks.gov/remedial/site_restoration/NCRARefinery.html. This website includes several Site documents relevant to the review of the recommended remedial approach.

This Draft CAD identifies the preferred remedial alternative to address soil and groundwater contamination at the Site. KDHE will select the final remedy for the Site after reviewing and considering information submitted during the 45-day public comment period – October 1, 2019 through November 15, 2019.

While the Draft CAD presents KDHE's preferred remedial alternative for the Site, KDHE may modify this alternative or select another remedial response action based on new information and/or public comments. A copy of this Draft CAD and other Site documents will be available for review at the McPherson Public Library, 214 West Marlin Street, McPherson, Kansas 67460. Selected documents related to the Site are also available for review at the KDHE offices in Topeka, Kansas during the public comment period. To review documents in Topeka, please contact Mr. John K. Cook 785-296-8986.

Public comments on the Draft CAD may be submitted to KDHE in writing, post-marked no later than November 15, 2019 (during the public comment period) at the address listed below.

Kansas Department of Health and Environment
Bureau of Environmental Remediation
1000 SW Jackson Street, Suite 410
Topeka, KS 66612
Attn.: John K. Cook, P.G., Site Restoration Unit
Phone: 785-296-8986

Comments on the Draft CAD may also be submitted to KDHE by electronic mail to john.cook@ks.gov . Comments sent electronically must be received by KDHE by 5:00 p.m., November 15, 2019.

11 TABLES

Table 1 – Summary of Historic Maximum and Current Maximum Contaminant Concentrations (milligrams per kilogram – mg/kg) in Soil

Contaminant of Concern	Non-Residential Tier 2 Level* (Soil Pathway) (mg/kg)	Location of Historic Maximum	Maximum Historic Concentration Detected (mg/kg)	Location of Current Maximum	Maximum Current Concentration Detected (mg/kg)
Benzene	0.168	EA 9/SWMU 10	**15.3**	Not identified in file documentation	ND
Toluene	51.2	EA 9/SWMU 10	16.2	EA 10/SWMU 11	2.28
Ethylbenzene	65.6	EA 9/SWMU 10	26.7	EA 10/SWMU 11	10.2
Xylene	809	EA 3/AOC 05	104.3	EA 10/SWMU 11	48.3
Naphthalene	0.659	EA 5/SWMU 28	**25.0**	EA 10/SWMU 11	**21.2**
TPH-GRO	450**	EA 3/AOC 05	**4,100**	EA 10/SWMU 11	**1,690**
TPH-DRO	20,000**	EA 8/SWMU 31	**35,500**	EA 8/SWMU 31	**35,500**
Lead	1,000	EA 8/SWMU 31	**1,570**	EA 8/SWMU 31	**1,570**
Arsenic	63.2	EA 8/SWMU 31	23.5	EA 8/SWMU 31	23.5
Chromium	111	EA 8/SWMU 25	**9,550**	EA 8/SWMU 25	**9,550**

** Risk-Based Standards for Kansas, RSK Manual – 5th Version, 2010 (revised 3/2014 and 9/2015).*

The RSK value noted in the table is the least between soil or soil to groundwater protection criteria.

*** TPH-GRO and TPH-DRO are no longer valid. However, the data were originally recorded in these now obsolete parameters.*

***Red** = detected/reported levels above RSK Screening Levels.*

This table does not reflect all constituents detected over the project lifecycle, but rather those parameters that are more common to petroleum sites.

ND = Non-detected (not detected above analytical methods)

Table 2 – Summary of Historic Maximum and Current Maximum Contaminant Concentrations (milligrams per liter – mg/L) in Groundwater

Contaminant of Concern	Residential Tier 2 Level* (Groundwater Pathway) (mg/L)	Date of Historical Maximum	Maximum Historic Concentration Detected (mg/L)	Current Maximum Concentration Detected (mg/L)
Benzene	**0.005**	8/5/2004	**1.2**	**0.146**
Toluene	**1.0**	5/24/2004	0.650	0.0914
Ethylbenzene	**0.7**	5/24/2004	**1.1**	0.0542
Xylene	**10**	5/24/2004	5.0	0.426
Naphthalene	**0.00111**	8/4/2004	**1.4**	**0.0340**
TPH-LRH	**0.350**	10/24/2017	**6.0**	**4.40**
TPH-MRH	**0.150**	11/15/2018	**82.40**	**82.40**
TPH-HRH	**1.0**	11/15/2018	**20.3**	**20.30**
TPH-GRO	n/a	5/24/2004	22.7	n/a
TPH-DRO	n/a	1/29/2015	1.1	n/a
Lead (Pb) - dissolved	**0.015**	11/14/2018	ND	ND
Arsenic (As) - dissolved	**0.010**	11/14/2018	**0.058**	**0.0568**
Chromium (Cr) - dissolved	**0.100**	11/14/2018	ND	ND

* *Risk-Based Standards for Kansas, RSK Manual – 5th Version, 2010 (revised 3/2014 and 9/2015)*

This table does not reflect all constituents detected over the project lifecycle, but rather more common (to petroleum sites) constituents.

ND = Non-detected (not detected above analytical method levels)

***Red** = detected/reported levels above RSK Screening Levels.*

n/a = not analyzed

Table 3 – Estimated Cost of the Alternatives

Component of Preferred Alternative	Estimated Timeframe for Implementation	Present Value Cost
Groundwater Monitoring and Underground Oil Recovery (UGOR) [1]	30 years	$1,339,951
Environmental Use Control Agreement (EUCA) Support and Oversight [2]	30 years	$635,868
One-Time Cost [3]	1 Year	$123,899
Decommissioning	Year 30	$30,391
Total Cost (6% discount rate)	**Net Present Value**	**$2,130,109**

Costs estimated by CHS Refinery

Includes recurring monitoring, groundwater level gauging, LNAPL recovery, maintenance, and reporting.

Includes recurring EUCA maintenance csot, consultant support, and KDHE oversight.

One-time costs include EUCA (fees, recording, etc.), Natural Source Zone Depletion (NSZD) and Tn study, Exposure Area 8 investigation, and sulfate pilot test

Costs associated with previous action already completed (interim or otherwise) are omitted from the Preferred Alternative estimate.

12 FIGURES

Figure 1 – Site Location

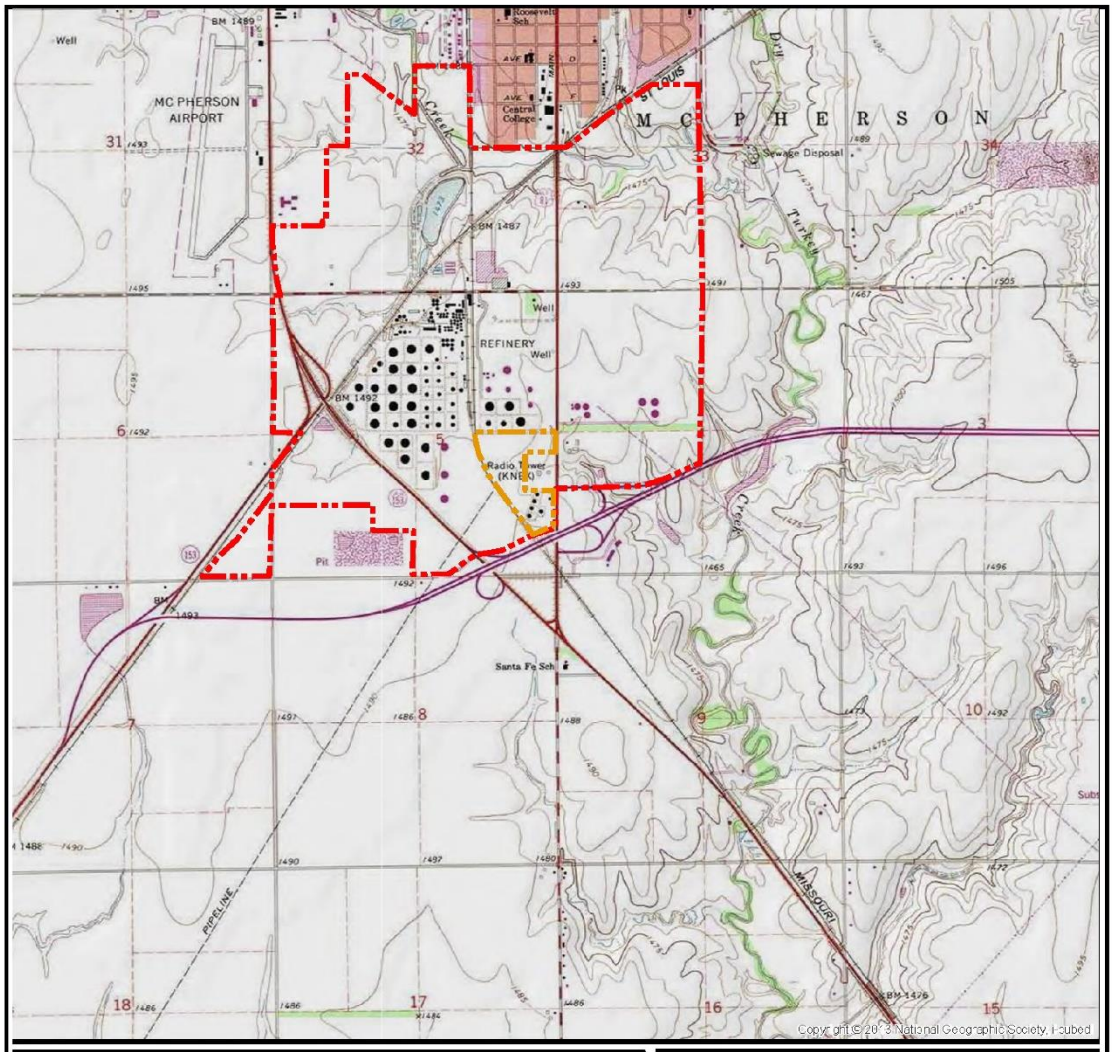


Figure 1-1 from Focused Corrective Action Study Report
22 June 2018

Kansas Department of Health and Environment

SITE:	NCRA Refinery C5-059-00057 McPherson, Kansas			
TITLE:	Site Location			
PROJECT PHASE:	Project Phase			
DRAWN BY:	CM	5/15/2019	BASEMAP DATE:	2018
CHECKED BY:	JC	5/15/2019	Figure 1	

Figure 2 – Site Vicinity Map

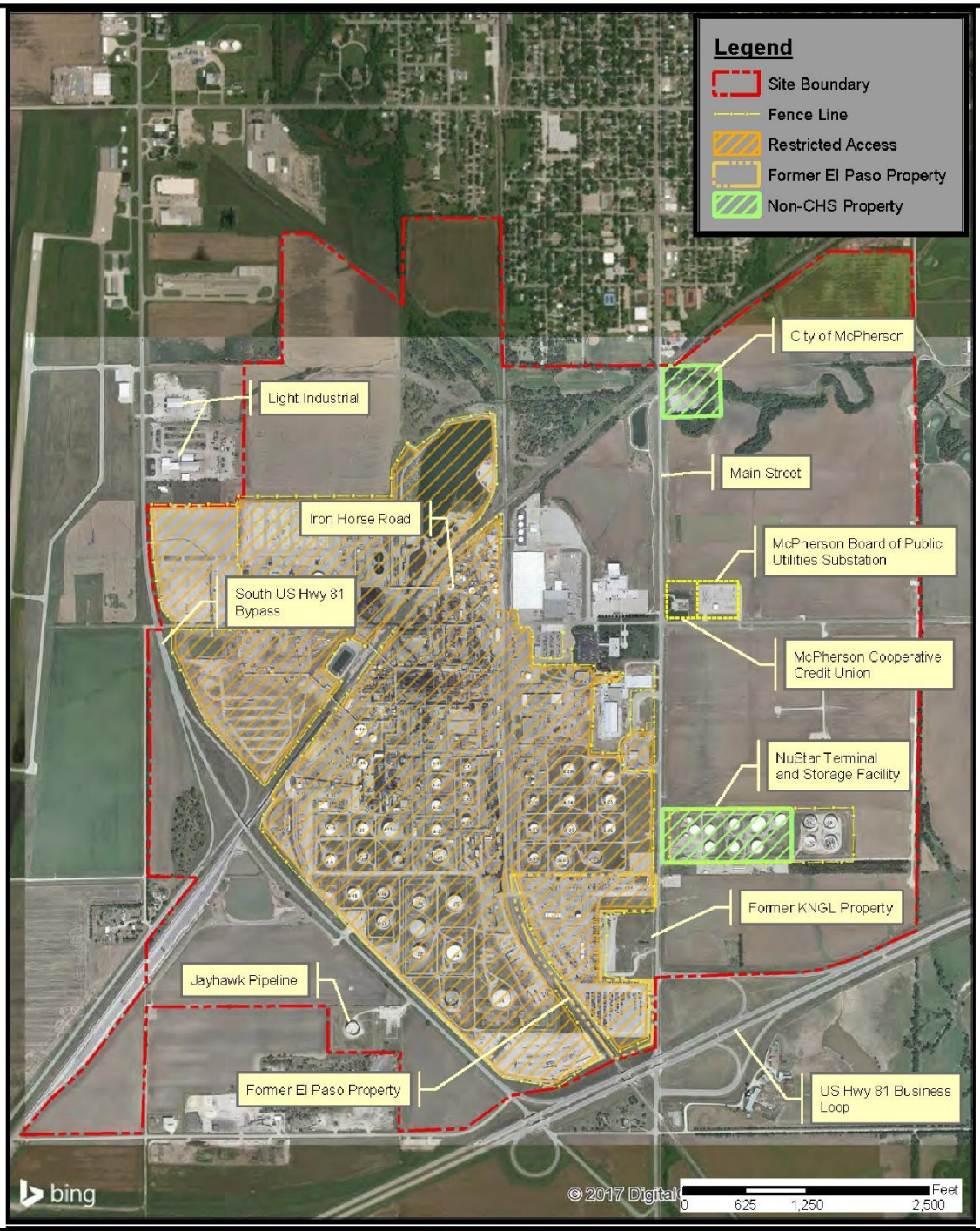


Figure 2-1 from Focused Corrective Action Study Report 22 June 2018

Kansas Department of Health and Environment

SITE:	NCRA Refinery C5-059-00057 McPherson, Kansas		
TITLE:	Site Vicinity Map		
PROJECT PHASE:	Project Phase		
DRAWN BY:	CM	5/15/2019	BASEMAP DATE: 2018
CHECKED BY:	JC	5/15/2019	Figure 2

Figure 3 – Groundwater Model, Particle Tracking

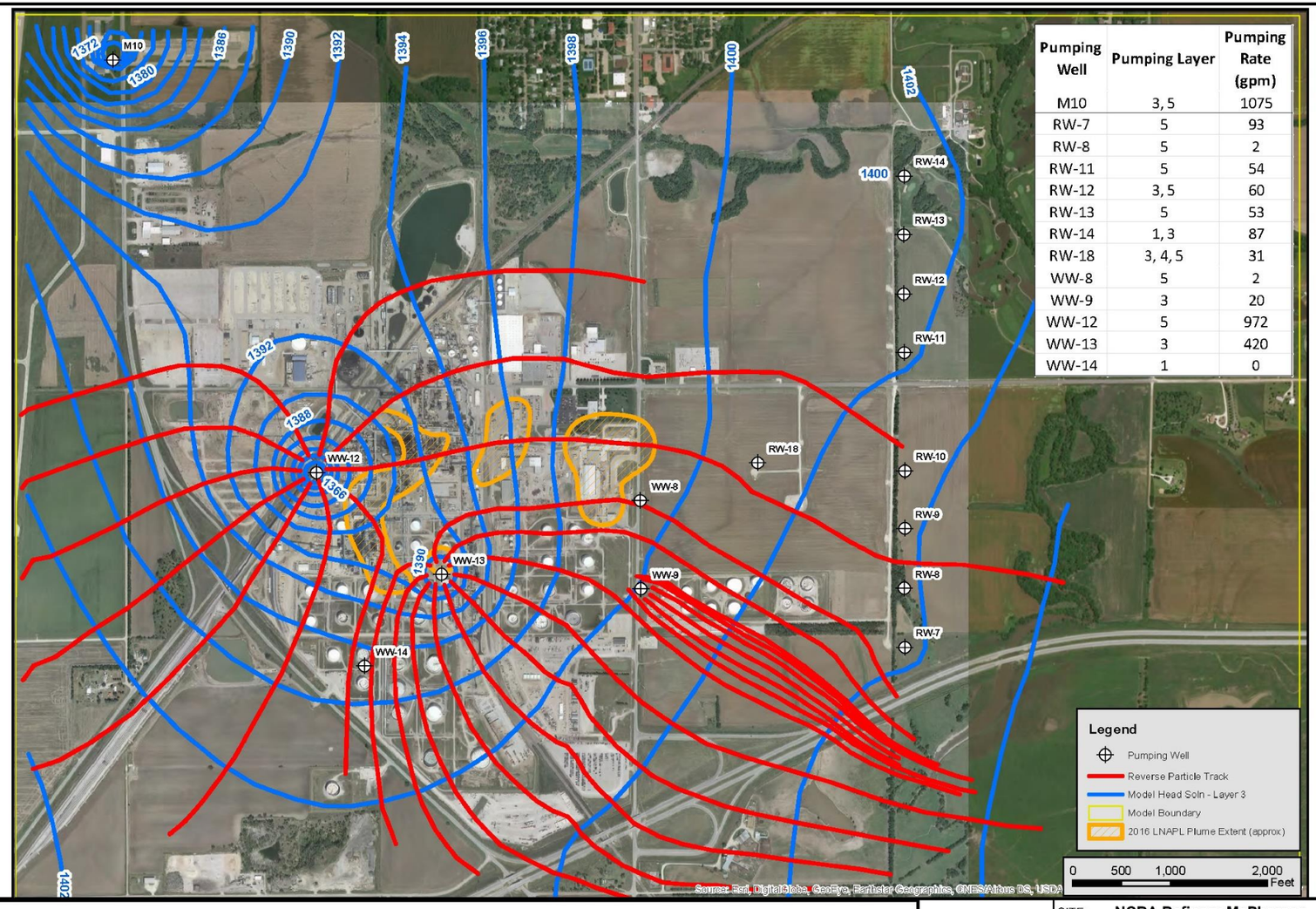
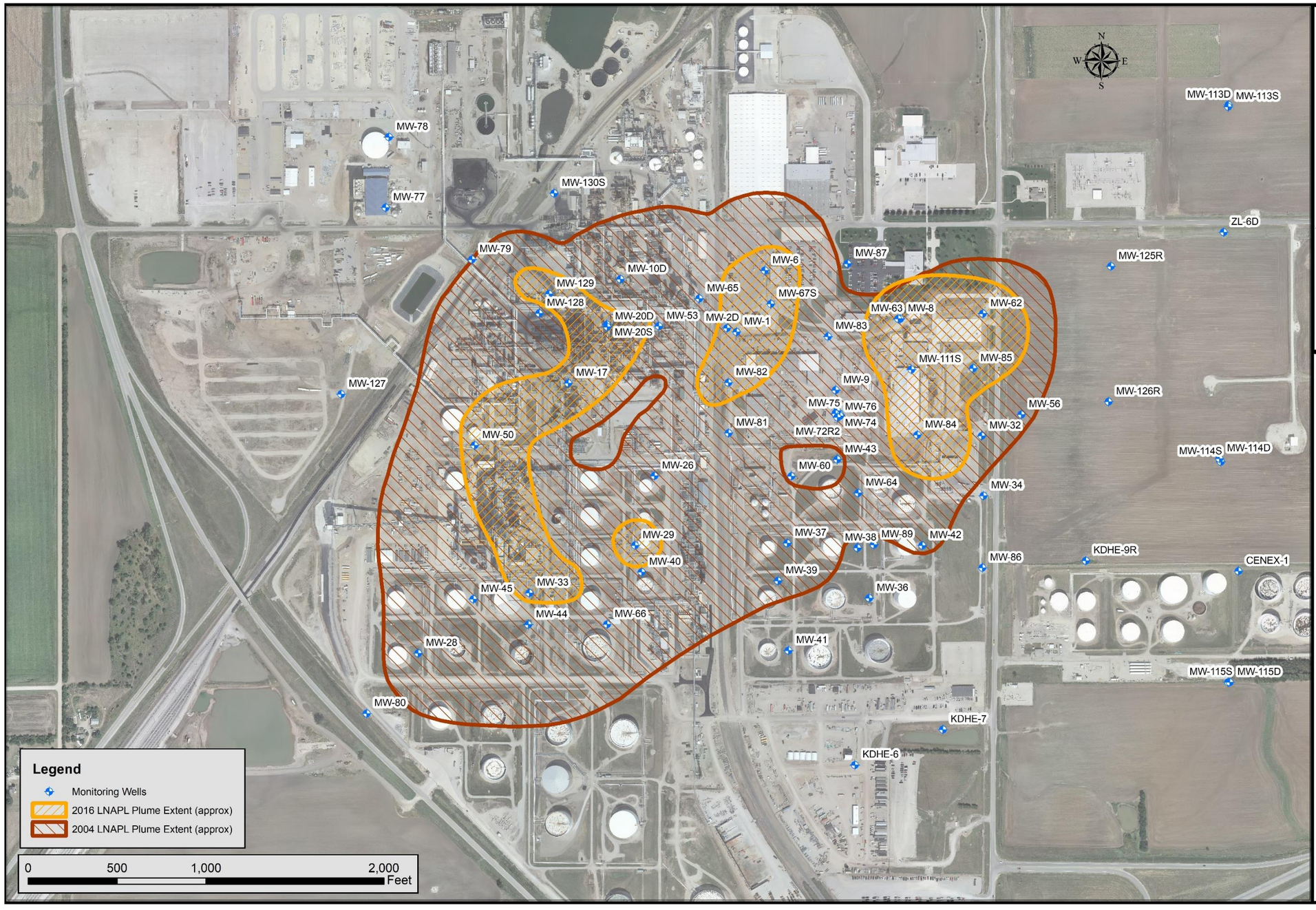


Figure 5-8 from Focused Corrective Action Study Report
CHS McPherson Refinery, Inc.
22 June 2018

Kansas Department of Health and Environment

SITE:	NCRA Refinery McPherson C5-059-00057 McPherson, Kansas			
TITLE:	Groundwater Model, Particle Tracking			
PROJECT PHASE:	Project Phase			
DRAWN BY:	CM	5/15/2019	BASEMAP DATE:	2018
CHECKED BY:	JC	5/15/2019	Figure 3	

Figure 4 – Comparative LNAPL Extent



SITE: NCRA Refinery McPherson C5-059-00057 McPherson, Kansas

TITLE: Comparative LNAPL Extent

PROJECT PHASE: Project Phase

DRAWN BY: CM 6/4/2019

CHECKED BY: JC 6/4/2019

BASEMAP DATE: 2018

Figure 4

Kansas Department of Health and Environment

Figure 5-3 from Focused Corrective Action Study Report
CHS McPherson Refinery, Inc.
22 June 2018